Patent
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HYDROGEN PEROXIDE AND PERACETIC ACID INDICATORS AND METHODS

BACKGROUND OF THE INVENTION

Medical instruments, particularly surgical instruments, are typically sterilized prior to use using steam or other sterilizing/disinfecting gases or liquids. A traditional sterilization process uses steam under pressure. Alternative sterilization processes use ethylene oxide or hydrogen peroxide in vapor form as the sterilant.

The use of hydrogen peroxide and other chemical vapor phase sterilization techniques typically involve operating temperatures well below those associated with steam sterilization. These "low temperature" technologies generally operate at temperatures below about 80°C, and often below about 65°C. For hydrogen peroxide sterilization, the sterilized goods are typically available for use shortly after the completion of the sterilization cycle. This is because the decomposition products (e.g., water and oxygen) are nontoxic. The potency of the hydrogen peroxide may be augmented by the presence of electrical energy in the form of an ionizing plasma field.

An alternative sterilization process uses a liquid phase peracetic acid solution. Such sterilization processes may be performed in a sterilization chamber. During a typical sterilization cycle, an article to be sterilized is exposed to a sterilization solution containing, for example, about 2000 parts per million (ppm) to 2500 ppm of peracetic acid. The article is exposed to the solution for a sufficient time at a sufficiently high temperature, e.g., 50°C-60°C, for the sterilization to be effective.

Sterilization indicators are used to monitor whether a sterilization process has been performed. Sterilization indicators typically include an indicator composition, carried on a substrate, that changes color during the

sterilization process. Conventional indicators for hydrogen peroxide, however, often fade upon exposure to light. Thus, there is still a need for suitable indicators that include color change compositions for indicating the sterilization of articles using hydrogen peroxide or peracetic acid.

SUMMARY OF THE INVENTION

The present invention is directed to indicators and methods for detecting the presence of, and for monitoring sterilization processes utilizing, a sterilant, including a hydrogen peroxide and/or a peracetic acid sterilant. The indicators and methods include an indicator including a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one colorant that changes color when exposed to a sterilant, at least one binder resin, and at least one salt of a transition metal.

In a preferred embodiment of the invention, the transition metal is selected from the group consisting of Group VB, Group VIII, and Group IB transition metals, and combinations thereof. The sterilization indicators of the present invention preferably include colorants that change color when exposed to hydrogen peroxide and/or peracetic acid. The sterilization indicators of the present invention preferably include a colorant selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Xanthene, Oxazine, Cyanine, Anthraquinone, Benzodifuranone, Styryl, Phthalocyanine, Quinophthalone, Nitro, and Nitroso colorants, and combinations thereof, and/or a colorant selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, and Basic red 14 colorants, and combinations thereof. Therefore, a sterilization indicator of the present invention may include a colorant that includes, for instance, a combination of a Methane and a Diazo colorant, a combination of Basic blue 41 and Basic red 15, or a combination of a Methane colorant and Basic blue 41. An even more preferred sterilization indicator includes an indicator composition further including at least one

colorant that does not change color when exposed to a sterilant, preferably hydrogen peroxide.

In one embodiment, the present invention is directed to methods and indicators for detecting the presence of hydrogen peroxide, preferably hydrogen peroxide in the vapor phase. The methods and indicators are particularly well suited for monitoring whether a hydrogen peroxide sterilization process has been performed.

In another embodiment, the present invention is directed to methods and indicators for detecting the presence of peracetic acid. The peracetic acid can be in the liquid phase or in the vapor phase. Preferably, the peracetic acid is in the liquid phase. The methods and indicators are well suited for monitoring whether a peracetic acid sterilization process has been performed.

The present invention provides a hydrogen peroxide indicator and a peracetic acid indicator that include a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one colorant, at least one metal salt, and at least one binder resin. Preferably, the metal salt is a transition metal salt. More preferably, the transition metal salt includes one or more metals from Groups VIB, VIII, and IB of the Periodic Chart, including iron, copper, cobalt, and chromium. Even more preferably, the transition metal salt includes metals from Groups VIII and IB of the Periodic Chart, including iron, copper, and cobalt, and combinations thereof. Most preferably, the transition metal salt includes iron and/or copper. The salts can include inorganic or organic anions. Examples include chloride, acetate, sulfate, chromate, iodate, molybdate, nitrate, oxalate, citrate, propionate, lactate, malate, tartrate, and benzoate. Preferred anions include chloride, acetate, and sulfate.

In a preferred embodiment, the hydrogen peroxide indicator includes: at least one salt of a transition metal; at least one colorant selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Xanthene, Oxazine, and Anthraquinone colorants, and combinations thereof, and/or at least one colorant selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986,

Keystone soap fluoro green, Basic red 14, and combinations thereof; and at least one binder resin. In a more preferred embodiment, the transition metal salt is selected from the group consisting of a copper salt, a cobalt salt, an iron salt, a chromium salt, and combinations thereof. In an even more preferred embodiment, the transition metal salt is at least one iron salt. In a still more preferred embodiment, the colorant is selected from the group consisting of Patent blue violet, Alkali blue 4B, Victoria pure blue BO, Acid fuchsin sodium salt, Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Eriochrome black T, Eriochrome blue black B, Cibacron brilliant red 3B, Chromotrope 2B, Amaranth, D&C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid Blue 113, Acid red 151, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Victoria pure blue BO, Acid fuchsin sodium salt, Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Eriochrome black T, Eriochrome blue black B, Cibacron brilliant red 3B, Chromotrope 2B, D&C red No. 33, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid blue 113, Acid red 151, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof. In a still more preferred embodiment, the hydrogen peroxide indicator

includes an indicator composition that further includes at least one colorant that does not change color when exposed to hydrogen peroxide vapor.

In another preferred embodiment, the hydrogen peroxide indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes: at least one salt of cobalt, copper, chromium, and combinations thereof; at least one colorant that changes color when exposed to hydrogen peroxide vapor; and at least one binder resin. In a preferred embodiment, the salt is selected from the group consisting of cobalt chloride, cobalt acetate, cupric chloride, cupric sulfate, cupric acetate, chromium potassium sulfate, and combinations thereof. In another preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Cyanine, Xanthene, Oxazine, and Anthraquinone colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In a further preferred embodiment, the indicator composition additionally includes at least one colorant that does not change color when exposed to hydrogen peroxide.

In another preferred embodiment, the hydrogen peroxide indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one cobalt salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin. In a more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Oxazine, and Anthraquinone colorants, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Patent blue violet, Aniline blue, Erioglaucine, Arsenazo 1, Acid blue 92, Eriochrome blue black B, Congo red, Acid blue 29, Nile blue A, Reactive blue 2, Basic red 15, D&C green No. 5, and combinations thereof.

In another preferred embodiment, the hydrogen peroxide indicator includes a substrate and an indicator composition disposed thereon, wherein the

indicator composition includes at least one copper salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin. In a more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Xanthene, Oxazine, Cyanine, and Anthraquinone colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Patent blue violet, Guinea green B, Coomassie violet R 150, Mordant brown 48, Chromotrope 2B, D&C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth, Acid red 151, Acid blue 29, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Azure B, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Alizarin violet 3R, Reactive blue 2, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, Fast green FCF, and combinations thereof. In a still more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Diazine, Thiazine, Xanthene, Oxazine, and Cyanine colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In a most preferred embodiment, the colorant is selected from the group consisting of Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Coomassie violet R 150, Mordant brown 48, Acid violet 5, Plasmocorinth, Acid red 151, Acid blue 29, Acid black 24, Acid

red 97, Direct red 75, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Rhodanine 6G, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Reactive blue 2, Victoria green S extra, Basic blue 41, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof.

In another preferred embodiment, the hydrogen peroxide indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one chromium salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin. In a more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, and Cyanine colorants, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Ethyl violet, Eriochrome black T, Eriochrome blue black B, Congo red, Acid blue 113, Quinaldine red, and combinations thereof. In a still more preferred embodiment, the colorant is selected from the group consisting of Ethyl violet, Eriochrome black T, Eriochrome blue black B, Acid blue 113, Quinaldine red, and combinations thereof.

In another embodiment, the present invention provides a peracetic acid indicator that includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes: at least one transition metal salt; at least one colorant selected from the group of classes of colorants consisting of Monoazo and Diazo colorants, and combinations thereof, and/or at least one colorant selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof; and at least one binder resin. In a preferred embodiment the indicator composition further includes at least one colorant that does not change color when exposed to peracetic acid.

In a preferred embodiment, the peracetic acid indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes: at least one salt of copper, cobalt, and combinations

thereof; at least one colorant that changes color when exposed to peracetic acid, preferably liquid peracetic acid; and at least one binder resin. In a more preferred embodiment, the indicator composition further includes at least one colorant that does not change color when exposed to peracetic acid.

In another preferred embodiment, the peracetic acid indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one copper salt, at least one colorant that changes color when exposed to peracetic acid, preferably liquid peracetic acid, and at least one binder resin. In a more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Monoazo and Diazo colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Acid violet 7, Evans blue, Naphthol blue black, Reactive black 5, Brilliant black BN, Azocarmine B, and combinations thereof.

In another preferred embodiment, the peracetic acid indicator includes a substrate and an indicator composition disposed thereon, wherein the indicator composition includes at least one cobalt salt, at least one colorant that changes color when exposed to peracetic acid, preferably liquid peracetic acid, and at least one binder resin. In a more preferred embodiment, the colorant is selected from the group of classes of colorants consisting of Monoazo and Diazo colorants, and combinations thereof. In an even more preferred embodiment, the colorant is selected from the group consisting of Cibacron brilliant red 3B, Evans blue, Reactive black 5, Brilliant black BN, and combinations thereof.

The invention also provides methods of monitoring a sterilization process, including a hydrogen peroxide sterilization process and a peracetic acid sterilization process. These methods include: providing an indicator including an indicator composition including at least one salt of a transition metal, at least one colorant that changes color when exposed to a sterilant, and at least one binder resin; providing an article to be sterilized; and exposing the article to be

sterilized and the indicator to a sterilant. The sterilant preferably includes hydrogen peroxide, preferably hydrogen peroxide vapor and/or peracetic acid, preferably liquid peracetic acid.

A method of monitoring a hydrogen peroxide sterilization process of the present invention includes: providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one salt of a transition metal, at least one colorant selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine Thiazine, Cyanine, Xanthene, Oxazine, Anthraquinone, Benzodifuranone, Styryl, Phthalocyanine, Quinophthalone, Nitro, and Nitroso colorants, and combinations thereof, and/or at least one colorant selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof, and at least one binder resin; providing an article to be sterilized; and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the salt of a transition metal is selected from the group consisting of cupric chloride, ferrous chloride, cobalt chloride, cobalt acetate, cupric sulfate, ferrous sulfate, chromium potassium sulfate, cupric acetate, and combinations thereof. In an even more preferred method, the indicator composition further includes a colorant that does not change color when exposed to hydrogen peroxide vapor.

In a preferred method of the present invention, the method includes: providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one salt of copper, chromium, iron, cobalt, and combinations thereof, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin; providing an article to be sterilized; and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine Cyanine, Xanthene, Oxazine, and Anthraquinone colorants, and combinations thereof,

and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof.

Another preferred method includes providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one cobalt salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin, providing an article to be sterilized, and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Oxazine, and Anthraquinone colorants, and combinations thereof. In an even more preferred method, the colorant is selected from the group consisting of Patent blue violet, Aniline blue, Erioglaucine, Arsenazo 1, Acid blue 92, Eriochrome blue black B, Congo red, Acid blue 29, Nile blue A, Reactive blue 2, Basic red 15, D&C green No. 5, and combinations thereof.

Another preferred method includes providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one copper salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin, providing an article to be sterilized, and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Xanthene, Oxazine, Cyanine, and Anthraquinone colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In an even more preferred method, the colorant is selected from the group consisting of Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Patent blue

violet, Guinea green B, Coomassie violet R 150, Mordant brown 48 Chromotrope 2B, D&C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth, Acid red 151, Acid blue 29, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Azure B, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Alizarin violet 3R, Reactive blue 2, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, Fast green FCF, and combinations thereof. In a still more preferred method, the colorant is selected from the group consisting of Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Coomassie violet R 150, Mordant brown 48, Acid violet 5, Plasmocorinth, Acid red 151, Acid blue 29, Acid black 24, Acid red 97, Direct red 75, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Rhodanine 6G, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Reactive blue 2, Victoria green S extra, Basic blue 41, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof.

Another preferred method includes providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one iron salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin, providing an article to be sterilized, and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Methane, Monoazo, Diazo, Triazo, Diazine, Thiazine, Cyanine, Xanthene, Oxazine, and Anthraquinone colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In an even more preferred method, the colorant is

selected from the group consisting of Patent blue violet, Alkali blue 4B, Victoria pure blue BO, Acid fuchsin sodium salt, Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Eriochrome black T, Eriochrome blue black B, Cibacron brilliant red 3B, Chromotrope 2B, Amaranth, D&C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid blue 113, Acid red 151, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof. In a still more preferred method, the colorant is selected from the group consisting of Victoria pure blue BO, Acid fuchsin sodium salt, Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Eriochrome black T, Eriochrome blue black B, Cibacron brilliant red 3B, Chromotrope 2B, D&C red No. 33, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid blue 113, Acid red 151, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D&C green No. 5, and combinations thereof.

Another preferred method includes providing a hydrogen peroxide indicator including a substrate and an indicator composition disposed thereon that includes at least one chromium salt, at least one colorant that changes color when exposed to hydrogen peroxide vapor, and at least one binder resin, providing an article to be sterilized, and exposing the hydrogen peroxide indicator and the article to be sterilized to hydrogen peroxide vapor. In a more preferred method, the colorant is selected from the group of classes of colorants

consisting of Methane, Monoazo, Diazo, and Cyanine colorants, and combinations thereof. In an even more preferred method, the colorant is selected from the group consisting of Ethyl violet, Eriochrome black T, Eriochrome blue black B, Congo red, Acid blue 113, Quinaldine red, and combinations thereof. In a still more preferred method, the colorant is selected from the group consisting of Ethyl violet, Eriochrome black T, Eriochrome blue black B, Acid blue 113, Quinaldine red, and combinations thereof.

A preferred method of monitoring a sterilization process of the present invention includes: providing a peracetic acid indicator including a substrate and an indicator composition disposed thereon that includes at least one salt of a transition metal, at least one colorant selected from the group of classes of colorants consisting of Monoazo, Diazo, Benzodifuranone, Styryl, Phthalocyanine, Quinophthalone, Nitro, and Nitroso colorants, and combinations thereof, and/or at least one colorant selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof, and at least one binder resin; providing an article to be sterilized; and exposing the peracetic acid indicator and the article to be sterilized to peracetic acid, preferably liquid peracetic acid. In a more preferred method, the salt of a transition metal is selected from the group consisting of cupric acetate, cobalt acetate, cupric sulfate, and combinations thereof.

In a preferred method of the present invention, the method includes: providing a peracetic acid indicator including a substrate and an indicator composition disposed thereon that includes at least one salt of copper, cobalt, and combinations thereof, at least one colorant that changes color when exposed to peracetic acid, and at least one binder resin; providing an article to be sterilized; and exposing the peracetic acid indicator and the article to be sterilized to peracetic acid, preferably liquid peracetic acid. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Monoazo and Diazo colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra,

Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof.

In a preferred method of the present invention, the method includes: providing a peracetic acid indicator including a substrate and an indicator composition disposed thereon that includes at least one copper salt, at least one colorant that changes color when exposed to peracetic acid, and at least one binder resin; providing an article to be sterilized; and exposing the peracetic acid indicator and the article to be sterilized to peracetic acid, preferably liquid peracetic acid. In a more preferred method, the colorant is selected from the group of classes of colorants consisting of Monoazo and Diazo colorants, and combinations thereof, and/or the colorant is selected from the group consisting of Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, Basic red 14, and combinations thereof. In a still more preferred method, the colorant is selected from the group consisting of Acid violet 7, Evans blue, Naphthol blue black, Reactive black 5, Brilliant black BN, Azocarmine B, and combinations thereof.

In another preferred method of the present invention, the method includes: providing a peracetic acid indicator including a substrate and an indicator composition disposed thereon that includes at least one cobalt salt, at least one colorant that changes color when exposed to peracetic acid, and at least one binder resin; providing an article to be sterilized; and exposing the peracetic acid indicator and the article to be sterilized to peracetic acid preferably liquid peracetic acid. In a more preferred method, the colorant is selected from the group consisting of Monoazo and Diazo colorants and combinations thereof. In a still more preferred method, the colorant is selected from the group consisting of Cibacron brilliant red 3B, Evans blue, Reactive black 5, Brilliant black BN, and combinations thereof.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In one embodiment, the present invention provides a sterilant indicator that includes a substrate on which is disposed an indicator composition that

includes at least one metal salt, preferably a transition metal salt, at least one of a select group of colorants, and at least one binder resin. Preferably, the sterilant is hydrogen peroxide and/or peracetic acid. As a result of exposure to a sterilant, the colorants change color, and even become colorless, thereby providing an indication of the presence of the sterilant and a method for monitoring a sterilization process.

One embodiment of the invention provides a hydrogen peroxide indicator that includes a substrate on which is disposed an indicator composition that includes at least one transition metal salt and at least one of a select group of colorants that changes color when exposed to hydrogen peroxide, and at least one binder resin. As a result of exposure to hydrogen peroxide, the colorants change color, and even become colorless, providing an indication of hydrogen peroxide presence.

In another embodiment, the present invention provides a peracetic acid indicator that includes a substrate on which is disposed an indicator composition that includes at least one metal salt, preferably a transition metal salt, at least one of a select group of colorants that changes color when exposed to peracetic acid, and at least one binder resin. As a result of exposure to peracetic acid, the colorants change color, thereby providing an indication of the presence of peracetic acid.

In particular, the present invention is directed to a system for indicating exposure to a hydrogen peroxide vapor sterilization process or a peracetic acid sterilization process, which may use either liquid peracetic acid or peracetic acid vapor. In one embodiment, the indicator composition includes at least one component that is transformed (typically, chemically transformed) when exposed to hydrogen peroxide vapor such that the color of the composition changes. In another embodiment, the indicator composition includes at least one component that is transformed (typically, chemically transformed) when exposed to liquid peracetic acid and/or peracetic acid vapor, preferably liquid peracetic acid, such that the color of the composition changes. The compositions may include one or more components that change color when

exposed to hydrogen peroxide and/or peracetic acid, as well as other components that do not change color when exposed to hydrogen peroxide and/or peracetic acid. The composition preferably includes a polymeric binder resin to aid in applying the composition to a suitable substrate.

Indicators of the present invention are very useful to show when an article has been exposed to hydrogen peroxide and/or peracetic acid. Significantly, indicators of the present invention offer one a simple, yet effective means for indicating when a particular article has been subjected to sterilization using hydrogen peroxide vapor and/or liquid peracetic acid or peracetic acid vapor.

Preferably, the hydrogen peroxide indicator compositions of the present invention undergo a color change when exposed to an atmosphere above an aqueous solution containing 30 weight percent (wt-%) hydrogen peroxide at 50°C within a period of at least about one hour and/or a color change when exposed to an atmosphere containing about 6 milligrams/liter (mg/l) to about 7 mg/l hydrogen peroxide (in an empty chamber, i.e., without articles to be sterilized) at a pressure of about 8×10^2 Pascals (Pa) to about 13.3×10^2 Pa and a temperature of about 45°C to about 50°C for a period of at least about 50 minutes, which are typical conditions within an empty commercial hydrogen peroxide plasma sterilizer. More preferably, for use in conventional sterilizers, the hydrogen peroxide indicator compositions of the present invention undergo a color change when exposed to an atmosphere containing about 6 mg/l to about 7 mg/l hydrogen peroxide (in an empty chamber) at a pressure of about 8×10^2 Pa to about 13.3×10^2 Pa and a temperature of about 45°C to about 50°C for a period of at least about 50 minutes. As used herein, a color change includes a change in color that is detectable by the unaided eye, including becoming colorless.

The peracetic acid indicator compositions of the present invention preferably undergo a color change when exposed to liquid and/or vapor phase peracetic acid. Preferably, the peracetic acid indicators undergo a distinct color change when exposed to an atmosphere containing at least 5% peracetic acid at

room temperature for at least 5 to 10 minutes. More preferably, the indicator compositions of the present invention undergo a color change when exposed to liquid peracetic acid at a concentration of between about 100 ppm to about 10,000 ppm at temperatures between about 0°C to about 100°C for between about 1 second to about 15 minutes. As used herein, a color change includes a change in color that is detectable by the unaided eye, including becoming colorless.

Preferably, the indicator compositions do not significantly fade upon exposure to room lighting, e.g., fluorescent lighting. More preferably, the indicator compositions do not significantly fade, for example, upon exposure to sunlight through a window for one week or room lighting for two months.

Colorants suitable for use in the indicator compositions of the present invention include colorants classified as Methane, Monoazo, Diazo, Triazo, Diazine, Cyanine, Thiazine, Xanthene, Oxazine, Anthraquinone, Benzodifuranone, Styryl, Phthalocyanine, Quinophthalone, Nitro, and Nitroso colorants, and combinations thereof, and/or colorants including Victoria green S extra, Basic blue 41, Basic red 15, Acid green AX986, Keystone soap fluoro green, and Basic red 14 colorants, and combinations thereof. Suitable colorants for use in the indicator compositions of the present invention further include Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Patent blue violet, Aniline blue, Victoria pure blue BO, Acid fuchsin sodium salt, Guinea green B, Alkali blue 4B, Coomassie violet R 150, Chromotrope 2B, D & C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth B, Cibacron brilliant red 3B, Amaranth, Arsenazo 1, Acid blue 92, Eriochrome blue black B, Eriochrome black T, Mordant brown 48, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Congo red, Acid blue 29, Acid blue 113, Acid red 151, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Azure B, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Alizarin violet 3R, Reactive blue 2, Victoria green

S extra, Basic blue 41, Acid green AX986, D & C green No. 5, Keystone soap fluoro green, Basic red 14, Brilliant black BN, Evans blue, Naphthol blue black, Xylidine ponceau 2R, Azocarmine B, and Fast green FCF. Alternative names and Color Index Numbers for these colorants are listed in Tables 1-13 below. Those colorants with classifications and/or Color Index Numbers that are difficult to determine are indicated in the tables as "Not Known." In this instance, "Not Known" means merely that determination of Colorant Class and/or Color Index Number is difficult, not necessarily that it is entirely unknown in the art. Various combinations of these colorants can be used in the indicator compositions of the present invention. Such mixtures or blends would increase the options available in color changes dramatically.

For hydrogen peroxide indicators, suitable colorants become colorless or change to a different color, detectable by the unaided eye, upon exposure to hydrogen peroxide vapor under conventional sterilization conditions (e.g., 6 mg/l to about 7 mg/l hydrogen peroxide in an empty chamber at a pressure of about 8 x 10^2 Pa to about 13.3 x 10^2 Pa and a temperature of about 45°C to about 50°C for a period of at least about 50 minutes) or to the more concentrated hydrogen peroxide vapors in a desiccator.

Preferably, at least one colorant is present in a hydrogen peroxide indicator composition in an amount sufficient to cause a visibly apparent color change when the composition is exposed to an atmosphere above an aqueous solution containing 30 wt-% hydrogen peroxide at 50°C within a period of at least about one hour and/or an amount sufficient to cause a color change when exposed to an atmosphere containing about 6 mg/l to about 7 mg/l hydrogen peroxide (in an empty chamber) at a pressure of about 8 x 10^2 Pa to about 13.3 x 10^2 Pa and a temperature of about 45°C to about 50°C for a period of at least about 50 minutes. Generally, the compositions contain about 0.1 wt-% to about 5.0 wt-%, based on the total weight of the composition, of a colorant that changes color upon exposure to hydrogen peroxide.

In effect, the colorant concentration should be such as to allow a clear visual indication of a color change. Preferred are those colorants that show

contrast between initial color and the color after exposure to hydrogen peroxide vapor. Examples include hydrogen peroxide indicators including cupric chloride and Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Chromotrope 2B, D&C red No. 33, Bordeaux R, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Direct blue 71, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D & C green No. 5, and combinations thereof (Tables 1b and 5); hydrogen peroxide indicators including cupric sulfate and Patent blue violet, Guinea green B, Methylene violet 3RAX, Azure B, Basic Red 15, Fast green FCF, and combinations thereof (Table 6); and hydrogen peroxide indicators including cupric acetate and Coomassie violet R 150, Mordant brown 48, Acid red 151, Acid blue 29, Reactive blue 2, and combinations thereof (Table 10).

If at least one colorant that does not change color upon exposure to hydrogen peroxide is used in the indicator compositions of the present invention, it is present, alone or in combination with one or more additional colorants, in an amount sufficient to provide the targeted color intensity, both prior to and subsequent to exposure to hydrogen peroxide vapor. Generally, such compositions contain about 0.1 wt-% to about 5.0 wt-%, based on the total weight of the composition, of a colorant that does not change color upon exposure to hydrogen peroxide.

Such colorants that become substantially colorless after exposure to hydrogen peroxide acid can also be used in combination with other colorants (e.g., dyes or pigments) that do not change color when exposed to hydrogen peroxide to give a chemical indicator with a suitable contrasting color change by subtracting color. For example, an indicator including the metal salt cupric

chloride with Cibacron brilliant red 3B (pale pink, Table 1b, No. 15) and Ethyl violet (blue, Table 1b, No. 5) would have a blue green color, as a result of the mixture of pale pink and blue. When exposed to hydrogen peroxide vapor, the Ethyl violet turns colorless (Table 1b, No. 5), leaving the pale pink of the Cibacron brilliant red 3B, which does not change color when exposed to hydrogen peroxide vapor (Table 1b, No. 15).

Preferred are those colorants that have an initial color and turns colorless after exposure to hydrogen peroxide vapor. Examples include hydrogen peroxide indicators including ferrous chloride and Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Cibacron brilliant red 3B, Chromotrope 2B, D&C red No. 33, Acid violet 7, Acid violet 5, Plasmocorinth B, Acid black 24, Acid red 97, Direct red 75, Brilliant crocein MOO, Ponceau SS, Reactive black 5, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Sulforhodamine B, Rhodanine 6G, Violamine R, Nile blue A, Basic blue 3, Brilliant cresyl blue BB, Basic red 15, Alizarin violet 3R, Victoria green S extra, Basic blue 41, Acid green AX986, Keystone soap fluoro green, Basic red 14, D & C green No. 5, and combinations thereof (Tables 2 and 7); hydrogen peroxide indicators including ferrous sulfate and Eriochrome black T, Eriochrome blue black B, Acid blue 113, Acid red 151, and combinations thereof (Table 8); hydrogen peroxide indicators including cupric chloride and Alphazurine A, Methyl violet 2B, Ethyl violet, FD/C blue 1, Brilliant blue R, Lissamine green B, Erioglaucine, Victoria pure blue BO, Acid fuchsin sodium salt, Acid violet 5, Plasmocorinth B, Acid black 24, Acid red 97, Direct red 75, Arsenazo 111, Azocarmine G, Methylene violet 3RAX, Toluidine blue O, Methylene green, Rhodanine 6G, Basic blue 3, Brilliant cresyl blue BB, Quinaldine red, Basic red 15, Victoria green S extra, Basic blue 41, Keystone soap fluoro green, Basic red 14, D & C green No. 5, and combinations thereof (Tables 1b and 5); hydrogen peroxide indicators including cobalt chloride and Patent blue violet, Aniline blue, Arsenazo 1, Acid blue 92, Congo red, Acid blue 29, and combinations

thereof (Table 3b); hydrogen peroxide indicators including cobalt acetate and Erioglaucine, Eriochrome blue black B, Nile blue A, Reactive blue 2, Basic red 15, D&C green No. 5, and combinations thereof (Table 4); hydrogen peroxide indicators including cupric sulfate and Methylene violet 3RAX (Table 6); hydrogen peroxide indicators including chromium potassium sulfate and Ethyl violet, Eriochrome black T, Eriochrome blue black B, Acid blue 113, Quinaldine red, and combinations thereof (Table 9); and hydrogen peroxide indicators including cupric acetate and Coomassie violet R 150 (Table 10).

For peracetic acid indicators, suitable colorants change to a different color upon exposure to liquid peracetic acid under conventional sterilization conditions. The peracetic acid indicator compositions of the present invention preferably undergo a color change when exposed to liquid and/or vapor phase peracetic acid. Preferably, the peracetic acid indicators undergo a distinct color change when exposed to an atmosphere containing at least 5% peracetic acid at room temperature for at least 5 to 10 minutes. More preferably, the indicator compositions of the present invention undergo a color change when exposed to liquid peracetic acid at a concentration of between about 100 ppm to about 10,000 ppm at temperatures between about 0°C to about 100°C for between about 1 second to about 15 minutes.

Preferably, at least one colorant is present in a peracetic acid indicator composition in an amount sufficient to cause a visibly apparent color change when the composition is exposed in a sterilization chamber to a sterilant including liquid peracetic acid at a concentration of 0.2 percent and a pH of 6.4 for about 12 minutes at a temperature of between about 50°C to about 56°C. The colorant concentration should be such as to allow a clear visual indication of a color change detectable by the unaided eye. Preferred colorants for peracetic acid indicators are those colorants that show contrast between the initial color and the color after exposure to liquid peracetic acid vapor. Examples include peracetic acid indicators including cupric acetate and Evans blue, Acid violet 7, Naphthol blue black, Reactive black 5, Brilliant black BN, Azocarmine B, and combinations thereof (Table 11); peracetic acid indicators

including cobalt acetate and Cibacron brilliant red 3B, Evans blue, Reactive black 5, Brilliant black BN, and combinations thereof (Table 12); and peracetic acid indicators including cupric sulfate and Evans blue, Acid violet 7, Naphthol blue black, Reactive black 5, Brilliant black BN, Azocarmine B, and combinations thereof (Table 13).

Preferably, hydrogen peroxide indicators and peracetic acid indicators of the present invention include a metal salt. Preferably the metal salt is a transition metal salt. More preferably, the metal salt includes one or more metals from Groups VIB, VIII, and IB of the Periodic Chart, which include iron, copper, cobalt, and chromium. Even more preferably, the metal salt includes metals from Groups VIII and IB of the Periodic Chart, which include iron, copper, cobalt, and combinations thereof. Most preferably, the metal salt includes iron and/or copper.

The salts can include inorganic or organic anions. Examples include chloride, acetate, sulfate, chromate, iodate, molybdate, nitrate, oxalate, citrate, propionate, lactate, malate, tartrate, and benzoate. Preferred anions include chloride, acetate, and sulfate.

The indicator composition is generally formulated in the form of a dispersion or solution in water or an organic solvent (preferably, an organic solvent). The composition includes at least one colorant as described above as well as an organic binder resins. A wide variety of suitable binder resins can be used. Examples include synthetic or natural polymers or resins. Suitable binder resins are those that do not interfere with the function of the indicator composition. Examples include cellulose acetate butyrate, cellulose acetate propionate, hydroxypropyl cellulose, nitrocellulose, urethane alkyd, epoxy, alkylated urea- and melamine-formaldehyde, polyamide, styrene butadiene, vinyl, phenolic, shellac, ethyl cellulose, methyl cellulose, acrylic, and ultraviolet and electron beam curable resins. A sufficient amount of binder resin is included in the compositions to provide adequate binding of the composition to a substrate on which it is disposed, while providing the desired rate of color change. Generally, the compositions contain about 20 wt-% to about 40 wt-% of

a polymer binder resin, based on the total weight of the composition.

Indicator compositions of the present invention can also include other resins that do not necessarily function as a binder resin. For example, the compositions can include a resin that functions as a dispersing agent, such as Rhoplex I-545, a water based acrylic polymer, available from Rohm and Haas Corp., Philadelphia, PA, that assists in dispersing the ingredients of the composition in the solvent used in application of the composition to a substrate. Indicator compositions of the present invention can also include opacifying agents such as titanium dioxide, surfactants, plasticizers, antifoam agents, and the like. For certain embodiments, a basic material such as an organic amine (e.g., triethanolamine) can be used to enhance sensitivity of the colorant to the low concentration of hydrogen peroxide in a conventional sterilizer. Typically, such additives are used in no more than about 5 wt-% based on the total weight of the indicator composition.

The compositions are typically applied to a substrate out of a solvent as discussed above. Suitable solvents include water and organic solvents such as ketones, esters, alcohols, and the like. Examples of suitable solvents include methyl ethyl ketone, n-propyl acetate, and isopropanol. The solvent is typically used in an amount of up to about 20 wt-%, based on the total weight of the composition. The indicator composition can be applied to the substrate by a wide variety of techniques, including, for example, printing or coating by flexographic, gravure, screen, or die processes.

The substrate on which the indicator composition is disposed can be any of a wide variety. Typically, suitable substrates include polymeric materials, which may be pigmented or colorless, such as polyester, polyethylene, or polystyrene films, nonwovens, paper, and the like. Preferably, it is a plastic polystyrene backing (commercially available from Plastic Suppliers, Inc., Chicago Heights, IL). The substrate may be in the form of a strip of material (e.g., a strip of material having the dimensions 2 cm by 13 cm). Optionally, the composition can be coated as a stripe over the length of the substrate strip. The substrate may also have an adhesive on the surface opposite that on which the

indicator composition is disposed. In this way, the indicator may be used as a tape or label for attachment to the article to be sterilized.

The hydrogen peroxide vapor sterilization procedure used is conventional, and is disclosed in, for example, U.S. Pat. Nos. 4,756,882, 4,643,876, 4,956,145, and 5,445,792. Preferably, it is a plasma-based sterilization system.

In general, the article to be sterilized is placed in a sterilization chamber with any of the preferred embodiments of hydrogen peroxide indicator of the invention, and a dose of hydrogen peroxide, which generally comes pre-measured, is delivered to the chamber. Vapor is generated and allowed to fill the container for an appropriate length of time after which the sterilization is complete. The indicator is then inspected for color change. The equipment and the entire procedure generally are controlled electronically. When sterilizing medical instruments, one cycle is often sufficient. The medical instruments are often packaged, with the entire package being placed into the sterilizing compartment. The package allows the hydrogen peroxide to penetrate and effect sterilization of the instruments, while subsequently protecting the instruments from contamination in air. The temperatures used in the process of the present invention are all generally less than 65°C.

The peracetic acid sterilization procedures that may be used are conventional, and are disclosed in, for example, U.S. Pat. Nos. 6,287,518 and 4,892,706. A conventional liquid peracetic acid sterilization procedure is disclosed in U.S. Pat. No. 4,892,706.

In general, the article to be sterilized is placed in a sterilization chamber with any of the preferred embodiments of peracetic acid indicator of the invention. Concentrated peracetic acid is then diluted in a buffer solution to form a sterilant solution, which is introduced to and circulated throughout the sterilization chamber. The article to be sterilized and the indicator are exposed to the sterilant solution for at least approximately 12 minutes at a temperature at or below about 60°C. The sterilization chamber is then drained and rinsed with

water. The rinsed article and indicator are removed from the sterilization chamber and the indicator is inspected for color change.

The invention will be illustrated in greater detail by the following specific examples. It is understood that these examples are given by way of illustration and are not meant to limit the disclosure or the claims to follow. All percentages in the examples, and elsewhere in the specification, are by weight unless otherwise specified.

EXAMPLES

CONTROL EXAMPLE A WITHOUT METAL SALTS

Control indicator compositions (Control Indicator Composition A) were prepared by shaking 10 milliliters (ml) of a binder-solution containing 7 wt-% percent of hydroxypropyl cellulose in 9 parts methanol: 1 part water, with approximately 0.1 gram (g) or a sufficient amount of colorant (0.1 wt-% to 5 wt-%) to give a good color in a glass vial. The colorants used to prepare these control indicator compositions are listed in Table 1a.

EXAMPLE 1

PREPARATION OF INDICATOR COMPOSITIONS

Indicator compositions (Indicator Composition 1) listed in Table 1b were prepared by adding 1 drop of a saturated cupric chloride water solution to the control indicator compositions described in Control Example A and shaking in the glass vial.

COATING OF INDICATOR COMPOSITIONS

Indicator compositions and control indicator compositions were coated on plastic polystyrene backing (commercially available from Plastic Suppliers Inc., Chicago Heights, IL) using a number 16 Meyer bar (commercially available from R. D. Specialties, Webster, NY). The coated inks were dried at 50°C in an oven (commercially available as "Despatch Style V 29" from Despatch Oven Co., Minneapolis, MN) for 2 minutes. The coated films were

cut using scissors to obtain indicators approximately 2 centimeters (cm) by 13 cm.

TEST METHOD

Each coated indicator composition and coated control indicator composition was placed on an instrument tray lid and exposed to a full Hospital 100 cycle of a hydrogen peroxide plasma sterilization procedure at 45-55°C in a STERRAD 100SI GMP Sterilizer, obtained from Advanced Sterilization Products Co., Irvine, CA. During the sterilization procedure a vacuum was drawn in the sterilization chamber for 5-6 minutes until the pressure was reduced to 40.0 Pa. A 1.8 ml aliquot of an aqueous solution of 58-60 percent hydrogen peroxide was then injected into the empty sterilization chamber, yielding an empty chamber concentration of 6-7 mg/l hydrogen peroxide. Hydrogen peroxide vapor was allowed to diffuse throughout the chamber for 44 minutes at 8×10^2 to 13.3×10^2 Pa. A vacuum was then drawn, reducing the pressure to 66.7 Pa and removing all detectable hydrogen peroxide vapor from the chamber. A plasma phase was then generated in the chamber by emitting an RF power source at 400 watts and 13.56 MegaHertz (MHz) for about 15-16 minutes at 66.7 Pa, after which the chamber was vented for 3-4 minutes until atmospheric pressure was reached in the chamber. After exposure to the sterilization procedure the indicators were removed from the tray lid and examined for color change. The results for each control indicator composition and indicator composition are described in Table 1a and Table 1b, respectively.

After the colorants were exposed to a full Hospital 100 cycle of hydrogen peroxide plasma sterilization procedure as described above, most of the control indicator compositions (Table 1a) did not change from their initial color. However, Victoria green S extra became colorless; Basic blue 41, Toluidine blue O, and Arsenazo 111 became lighter; Quinaldine red and Alkali blue 4B became slightly lighter; and Violamine R changed from a light pink to pink/violet (darker).

After cupric chloride was added to the indicator composition, most of the colorants either became colorless or significantly lighter when exposed to hydrogen peroxide plasma as described above (Table 1b). The colorants including cupric chloride that did not change or changed so slightly as to make the change difficult to see with the human eye were Cibacron brilliant red 3B, Amaranth, and Brilliant black BN; Nile blue A changed from light blue to light gray; Bordeaux R changed from light pink to a slightly lighter pink; Direct red 75 changed from almost colorless to colorless; and Ponceau SS changed from pink/beige to light purple/pink.

As demonstrated in Example 2, below (Table 2), the choice of metal ion can affect the color change. For instance an indicator composition including one metal ion can produce a color change in an indicator composition exposed to a sterilant that is different from that of an indicator composition including the same colorant with a different metal ion that is also exposed to a sterilant. Compare, for example, the colorant Chromotrope 2B listed in Table 2, No. 7 (with ferrous chloride) that turns colorless with Chromotrope 2B listed in Table 1b, No. 57 (with cupric chloride) that turns beige.

EXAMPLE 2

PREPARATIONS OF INDICATOR COMPOSITIONS USING FERROUS CHLORIDE

Indicator compositions (Indicator Composition 2, Table 2) were prepared by adding 1 drop of a saturated ferrous chloride water solution to the control indicator compositions described in Control Example A and shaking in the glass vial. The colorants used with the ferrous chloride are listed in Table 2.

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition (Control Indicator Composition A) and Indicator Composition 2 are shown in Table 1a and Table 2, respectively.

After the addition of ferrous chloride to the control composition, each of the colorants listed in Table 2 either became colorless or significantly lighter when exposed to hydrogen peroxide plasma as described above.

CONTROL EXAMPLE B WITHOUT METAL SALTS

Control indicator compositions (Control Indicator B, Table 3a) were prepared by shaking 10 milliliters (ml) of a binder solution containing 5 wt-% of hydroxypropyl cellulose in 6 parts methanol: 4 parts water, with approximately 0.1 g or a sufficient amount of colorant (0.1 wt-% to 5 wt-%) to give a good color in a glass vial. The colorants used in the Control Indicator Composition B for Examples 3 – 10 are listed in Table 3a.

EXAMPLE 3

PREPARATION OF INDICATOR COMPOSITIONS USING COBALT CHLORIDE

A drop of cobalt chloride salt solution containing 1 g of salt to 3.25 g of water was added to the control indicator composition described in Control Example B and shaken in a glass vial. The colorants used with cobalt chloride are listed in Table 3b.

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each Control Indicator Composition B and Indicator Composition 3 are shown in Table 3a and Table 3b respectively.

After the colorants were exposed to a full Hospital 100 cycle of hydrogen peroxide plasma sterilization procedure as described above, most of the colorants did not change from their initial color. However, Guinea green B became almost colorless; Acid fuchsin sodium salt became lighter; Nile blue A, Arsenazo 1, Basic red 14, Basic red 15, and Alkali blue 4B became slightly lighter; Azure B became significantly lighter, Aniline blue changed from blue to

gray/green; Quinaldine red changed from muddy pink to light pink, and Acid blue 92 changed from lilac to light violet.

After the addition of cobalt chloride to the control composition, all of the colorants listed in Table 3b became colorless when exposed to hydrogen peroxide plasma as described above.

EXAMPLE 4

PREPARATION OF INDICATOR COMPOSITIONS USING COBALT ACETATE

Indicator compositions were prepared as described in Example 3 except a drop of cobalt acetate salt solution containing 1 g of salt to 3.25 g of water was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 4

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition and Indicator Composition 4 are shown in Table 3a and Table 4, respectively.

After the addition of cobalt acetate to the control composition each of the colorants listed in Table 4 became colorless when exposed to hydrogen peroxide plasma as described above.

EXAMPLE 5

PREPARATION OF INDICATOR COMPOSITIONS USING CUPRIC CHLORIDE

Indicator compositions were prepared as described in Example 3 except four drops of cupric chloride salt solution containing 1 g of salt to 13 g of water was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 5

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition and Indicator Composition 5 are shown in Table 3a and Table 5, respectively.

After the addition of cupric chloride to the control composition, each of the colorants listed in Table 5 became colorless when exposed to hydrogen peroxide plasma as described above.

EXAMPLE 6

PREPARATION OF INDICATORCOMPOSITIONS USING CUPRIC SULFATE

Indicator compositions were prepared as described in Example 3 except four drops of cupric sulfate salt solution containing 1 g of salt to 13 g of water was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 6

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition and Indicator Composition 6 are shown in Table 3a and Table 6, respectively.

The addition of cupric sulfate to the control composition of the colorants listed in Table 6 did not show as dramatic results as the preceding examples. Each colorant changed color when exposed to hydrogen peroxide plasma as described above; however, Azure B became clear, Methylene violet 3RAX became almost colorless, and Basic red 15 became significantly lighter. Patent blue violet changed from green/blue to green/gray; Guinea green B and Fast green FCF changed from green to a mottled green on clear when exposed to hydrogen peroxide plasma.

EXAMPLE 7

PREPARATION OF INDICATOR COMPOSITIONS USING FERROUS CHLORIDE

Indicator compositions were prepared as described in Example 3 except a drop of ferrous chloride salt solution containing 1 g of salt to 3.25 g of water

was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 7.

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition and Indicator Composition 7 are shown in Table 3a and Table 7, respectively.

After the addition of ferrous chloride to the control composition, the colorants listed in Table 7 became colorless when exposed to hydrogen peroxide plasma as described above.

EXAMPLE 8

PREPARATION OF INDICATOR COMPOSITIONS USING FERROUS SULFATE

Indicator compositions were prepared as described in Example 3 except four drops of ferrous sulfate salt solution containing 1 g of salt to 13 g of water was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 8

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition and Indicator Composition 8 are shown in Table 3a and Table 8, respectively.

After the addition of ferrous sulfate to the control composition, each of the colorants either became colorless, almost colorless, or significantly lighter when exposed to hydrogen peroxide plasma as described above.

EXAMPLE 9

PREPARATION OF INDICATOR COMPOSITIONS USING CHROMIUM POTASSIUM SULFATE

Indicator compositions were prepared as described in Example 3 except a drop of chromium potassium sulfate salt solution containing 1 g of salt to 3.25 g of water was added to the initial composition and shaken in a glass vial. The

colorants used are listed in Table 9. Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example

The results for each control indicator composition and Indicator Composition 9 are shown in Table 3a and Table 9, respectively.

After the addition of chromium potassium sulfate to the control composition, each of the colorants except Congo red became colorless when exposed to hydrogen peroxide plasma as described above. Congo red changed from red to brown, which is a significant change to be seen by the human eye.

EXAMPLE 10

PPREPARATION OF INDICATOR COMPOSITIONS USING CUPRIC ACETATE

Indicator compositions were prepared as described in Example 3 except a drop of cupric acetate salt solution containing 1 g of salt to 3.25 g of water was added to the initial composition and shaken in a glass vial. The colorants used are listed in Table 10.

Indicator compositions and control indicator compositions were coated on plastic backings and sterilized as described in Example 1.

The results for each control indicator composition B and Indicator Composition 10 are shown in Table 3a and Table 10, respectively.

After the addition of cupric acetate to the control composition, the colorants listed in Table 10 became almost colorless, significantly lighter, or lighter except Xylidine ponceau 2R when exposed to hydrogen peroxide plasma as described above. Xylidine ponceau 2R did not change color with the addition of cupric acetate and exposure to hydrogen peroxide plasma.

EXAMPLE 11

PREPARATION OF INDICATOR COMPOSITIONS WITH CUPRIC ACETATE AND DEVICE

Indicator compositions were prepared by dissolving 0.3 g of colorant in 90 ml of water. The colorants are listed in Table 11. The resulting solution was divided equally into 3 boats. A control indicator was made by immersing an 11 cm circle of Whatman Grade 1 filter paper in the solution, allowing the excess solution to drip from the paper, and drying for approximately 1 hour. The color of the dried control is recorded in Table 11.

A second solution (Indicator Composition 11) was prepared by adding 1.0 g of a cupric acetate $\{Cu(C_2H_3O_2)_2 \cdot H_2O\}$ (available from Mallinckrodt, Inc., Hazelwood, MO) to 13 ml of water.

Five ml of the second solution was added to the solution in each boat. Three more 11 cm circles of filter paper were immersed one in each boat, allowed to drip and dried like the control. The color of the dried colorant and metallic salt composition is recorded in Table 11.

Adhesive (3M VHB acrylate adhesive on a release liner) was applied by transfer of the adhesive from the release liner to one side of each dried filter paper. A 1.9 cm (0.75 inch) circle was cut from the adhesive backed filter paper. The smaller adhesive circle was applied to the center of a 5.08 cm square (2 inch) by 0.25 millimeter (0.01 inch) thick piece of TYVEK type 10 1025 D spunbond olefin backing, available from E. I. du Pont de Nemours and Company, Wilmington, DE. The circle was enclosed within a device in the following manner. A 5.08 cm (2 inch) square by 0.25 mm (0.01 inch) thick piece of polyvinyl chloride (available as PJN-9708623 from Perfecseal, Minneapolis, MN) having a central 2.54 cm (1 inch) square by 0.95 cm (3/8 inch) deep vapor head space was glued using, Loctite 411 instant adhesive, to the spunbond backing.

TEST METHOD

The devices were processed in the STERIS SYSTEM 1 sterilizer, obtained from STERIS Corporation, Mentor, Ohio. The devices were sealed in the sterilizer and exposed to a preliminary wash with an anticorrosive buffer solution. Sixty (60) ml of 35 percent liquid peracetic acid was then introduced to the buffer solution and circulated throughout the sterilization chamber for 12 minutes at 50-56°C. The circulating sterilant had a liquid peracetic acid concentration of 0.2 percent and a pH of 6.4. The sterilant was then drained and the sterilizing chamber was washed with water four times. The devices were removed and examined visually for color changes. The results are recorded in Table 11. Some of the devices changed color on the edges of the circle, but retained the initial color in the center. New indicator devices were tested without applying an adhesive coating to the back of the colored filter paper. The results of Examples 11-13 are noted in Tables 11, 12, and 13.

EXAMPLE 12

PREPARATION OF INDICATOR COMPOSITIONS WITH COPPER SULFATE AND DEVICES

Indicator compositions were prepared as for Example 11. The colorants used are listed in Table 12. The second solution (Indicator Composition 12) was prepared by adding 1.0 g of copper sulfate ($CuSO_4 \cdot 5H_2O$) (available from Mallinckrodt, Inc., Hazelwood, MO) to 13 ml of water. Devices were prepared and tested as described in Example 11. The results are recorded in Table 12.

EXAMPLE 13

PREPARATION OF INDICATOR COMPOSITIONS WITH COBALT ACETATE AND DEVICES

Indicator compositions were prepared as for Example 11. The colorants used are listed in Table 13. The second solution (Indicator Composition 13) was prepared by adding 1.0 g of cobalt(II) acetate tetrahydrate $\{Co(C_2H_3O_2)_2 \cdot 4H_2O\}$

(available from Sigma-Aldrich Fine Chemicals, St. Louis, MO) to 13 ml of water. Devices were prepared and tested as described in Example 11. The results are recorded in Table 13.

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Table 1a Control Indicator Composition A Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
1	[1]Alphazurine A	Methane	42080	Blue/green	None
2	[1]Azocarmine G	Diazine	50085	Purple/pink	None
3	Victoria green S extra	Not known	Not known	Green	Colorless
4	[1]Methyl violet 2B (*Basic violet 1)*	Methane	42535	Purple	None
5	[1]Ethyl violet (*Basic violet 4)*	Methane	42600	Blue	None
6	[1]Alizarin violet 3R	Anthraquinone	61710	Light lilac	None
7	[1]Basic blue 41	Not known	Not known	Dark lilac	Lighter
8	[4]FD/C blue 1	Methane	42090	Light blue	None
9	[1]Toluidine blue O (*Basic blue 17 or Tolonium chloride)*	Thiazine	52040	Violet	Lighter
10	[1]Nile blue A	Oxazine	51180	Purple/blue	None

Table 1a Control Indicator Composition A Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
11	[1]Quinaldine red	Cyanine	None	Red/gray	Slightly lighter
12	[1]Basic blue 3	Oxazine	51004	Blue/green	None
13	[1]Acid black 24	Diazo	26370	Blue/black	None
14	[1]Acid red 97	Diazo	22890	Orange	None
15	[1]Cibacron brilliant red 3B	Monoazo	Not known	Pale pink	None
16	[1]Sulforhodamine B	Xanthene	45100	Hot pink	None
17	[1]Direct blue 71	Triazo	34140	Purple/black	None
18	[1]Chromotrope 2B	Monoazo	16575	Pink-beige	None
19	[1]Brilliant blue R (*Acid blue 83 or Coomassie brilliant blue R*)	Methane	42660	Blue	None
20	[1]Amaranth	Monoazo	16185	Pink/gray	None
21	[1]Rhodanine 6G	Xanthene	45160	Hot pink	None

Table 1a Control Indicator Composition A Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
22	[5]Brilliant cresyl blue BB	Oxazine	51010	Blue	None
23	[3]D & C red No. 33	Monoazo	17200	Red	lilac
24	[1]Bordeaux R	Monoazo	16180	Light pink	None
25	[1]Direct red 75	Diazo	25380	Pale pink	None
26	[1]Acid violet 7	Monoazo	18055	Lilac	None
27	[1]Acid violet 5	Monoazo	18125	Dark pink	None
28	[1]Plasmocorinth B	Monoazo	16680	Dark pink	None
29	[1]Brilliant crocein MOO	Diazo	27290	Orange	None
30	[1]Methylene green	Thiazine	52020	Pale blue/gray	Pale pink/gray
31	[1]Methylene violet 3RAX	Diazine	50206	Pink	None
32	[1]Ponceau SS	Diazo	27190	Pink/beige	None
33	[1]Reactive black 5	Diazo	20505	Blue/black	None

Table 1a Control Indicator Composition A Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
34	[2]Basic red 15	Not known	Not known	Hot pink	None
35	[3]Acid green AX986	Not known	Not known	Lime green	None
36	[1]Lissamine green B (*Acid Green 50 or Wool Green S)*	Methane	44090	Blue/green	None
37	[1]Erioglaucine	Methane	42090	Blue/green	None
38	[1]Violamine R	Xanthene	45190	Light pink	Pink/violet
39	[1]Brilliant black BN	Diazo	28440	Dark gray	None
40	[1]Arsenazo 111	Diazo	None	Dark lilac	Lighter
41	[3]Alkali blue 4B	Methane	42750	Blue	Slightly lighter
42	[3]Coomassie violet R 150	Methane	42650	Grey/blue	None
43	[1]Acid blue 92	Monoazo	13390	Lilac	Light violet
44	[1]Acid blue 29	Diazo	20460	Grey/blue	None
45	[1]Xylidine ponceau 2R	Monoazo	16150	Orange	None

Table 1a Control Indicator Composition A Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
46	[1]Reactive blue 2	Anthraquinone	61211	Blue/gray	None

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4]Commercially available from Warner-Jenkinson, St. Louis, MO.

[5] Commercially available from Kodak, Rochester, NY

Table 1b Indicator Composition 1 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
1	[1]Alphazurine A	Methane	42080	Blue/green	Blue/green	Almost colorless
2	[1]Azocarmine G	Diazine	50085	Purple/pink	Purple/pink	Significantly lighter
3	Victoria green S extra	Not known	Not known	Green	Green	Colorless
4	[1]Methyl violet 2B (*Basic violet 1)*	Methane	42535	Purple	Purple	Colorless
5	[1]Ethyl violet (*Basic violet 4)*	Methane	42600	Blue	Blue	Colorless
6	[1]Alizarin violet 3R	Anthraquinone	61710	Light lilac	Light lilac	Lighter
7	[1]Basic blue 41	Not known	Not known	Dark lilac	Dark lilac	Colorless
8	[4]FD/C blue 1	Methane	42090	Light blue	Light blue	Almost colorless
9	[1]Toluidine blue O (*Basic blue 17 or Tolonium chloride)*	Thiazine	52040	Violet	Blue/gray	Colorless

Table 1b Indicator Composition 1 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
10	[1]Nile blue A	Oxazine	51180	Purple/blue	Very Light blue, Almost Colorless	Light gray
11	[1]Quinaldine red	Cyanine	None	Red/gray	Pale pink/gray	Colorless
12	[1]Basic blue 3	Oxazine	51004	Blue/green	Blue	Colorless
13	[1]Acid black 24	Diazo	26370	Blue/black	Blue/black	Colorless
14	[1]Acid red 97	Diazo	22890	Orange	Orange	Colorless
15	[1]Cibacron brilliant red 3B	Monoazo	Not known	Pale pink	Pale pink	No change
16	[1]Sulforhodamine B	Xanthene	45100	Hot pink	Hot pink	Very light pink
17	[1]Direct blue 71	Triazo	34140	Purple/black	Purple/black	Slightly lighter
18	[1]Chromotrope 2B	Monoazo	16575	Pink-beige	Dark gray	Beige

Table 1b Indicator Composition 1 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
19	[1]Brilliant blue R (*Acid blue 83 or Coomassie brilliant blue R)*	Methane	42660	Blue	Blue	Colorless
20	[1]Amaranth	Monoazo	16185	Pink/gray	Pink/gray	No change
21	[1]Rhodanine 6G	Xanthene	45160	Hot pink	Hot pink	Almost colorless
22	[5]Brilliant cresyl blue BB	Oxazine	51010	Blue	Blue	Colorless
23	[3]D & C red No. 33	Monoazo	17200	Red	Purple/pink	Tan
24	[1]Bordeaux R	Monoazo	16180	Light pink	Light pink	Slightly lighter
25	[1]Direct red 75	Diazo	25380	Pale pink	Almost colorless	Colorless
26	[1]Acid violet 7	Monoazo	18055	Lilac	Lilac	Very light lilac
27	[1]Acid violet 5	Monoazo	18125	Dark pink	Light red	Colorless
28	[1]Plasmocorinth B	Monoazo	16680	Dark pink	Light violet	Colorless

Table 1b Indicator Composition 1 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
29	[1]Brilliant crocein MOO	Diazo	27290	Orange	Light red	Very pale orange
30	[1]Methylene green	Thiazine	52020	Pale blue/gray	Pale blue/gray	Colorless
31	[1]Methylene violet 3RAX	Diazine	50206	Pink	Pink	Colorless
32	[1]Ponceau SS	Diazo	27910	Pink/beige	Pink/beige	Light purple/pink
33	[1]Reactive black 5	Diazo	20505	Blue/black	Blue/black	Beige
34	[3]Basic red 15	Not known	Not known	Hot pink	Hot pink	Colorless
35	[2]Acid green AX986	Not known	Not known	Lime green	Lime green	Tan
36	[1]Lissamine green B (*Acid Green 50 or Wool Green S)*	Methane	44090	Blue/green	Blue/green	Colorless
37	[1]Erioglaucine	Methane	42090	Blue/green	Blue/green	Colorless
38	[1]Violamine R	Xanthene	45190	Light pink	Pink/violet	Very light pink
39	[1]Brilliant black BN	Diazo	28440	Dark gray	Dark gray	No change

Table 1b Indicator Composition 1 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
40	[1]Arsenazo 111	Diazo	None	Dark lilac	Blue/black	Almost colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Comm ercially available from ICN Biomedicals, Costa Mesa, CA.

[4]Commercially available from Warner-Jenkinson, St. Louis, MO.

[5]Commercially available from Kodak, Rochester, NY.

Table 2 Indicator Composition 2 Colorants and Results after Sterilization

No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
1	[1]Alphazurine A	Methane	42080	Blue/green	Blue/green	Colorless
2	[1]Azocarmine G	Diazine	50085	Purple/pink	Purple/pink	Colorless
3	Victoria green S extra	Not known	Not known	Green	Green	Colorless
4	[1]Methyl violet 2B (*Basic violet 1)*	Methane	42535	Purple	Purple	Colorless
5	[1]Ethyl violet (*Basic violet 4)*	Methane	42600	Blue	Blue	Colorless
6	[1]Alizarin violet 3R	Anthraquinone	61710	Light lilac	Light lilac	Colorless
7	[1]Basic blue 41	Not known	Not known	Dark lilac	Dark lilac	Colorless
8	[4]FD/C blue 1	Methane	42090	Light blue	Light blue	Colorless
9	[1]Toluidine blue O	Thiazine	52040	Violet	Blue/gray	Colorless
10	[1]Nile blue A	Oxazine	51180	Purple/blue	Blue/green	Colorless

Table 2 Indicator Composition 2 Colorants and Results after Sterilization

No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
11	[1]Quinaldine red	Cyanine	None	Red/gray	Pink/gray	Colorless
12	[1]Basic blue 3	Oxazine	51004	Blue/green	Blue/green	Colorless
13	[1]Acid black 24	Diazo	26370	Blue/black	Blue/black	Colorless
14	[1]Acid red 97	Diazo	22890	Orange	Orange	Colorless
15	[1]Cibacron brilliant red 3B	Monoazo	Not known	Pale pink	Pale pink	Colorless
16	[1]Sulforhodamine B	Xanthene	45100	Hot pink	Hot pink	Colorless
17	[1]Direct blue 71	Triazo	34140	Purple/black	Purple/black	Significantly lighter
18	[1]Chromotrope 2B	Monoazo	16575	Pink-beige	Pink-beige	Colorless
19	[1]Brilliant blue R *(Acid blue 83 or Coomassie brilliant blue R)*	Methane	42660	Blue	Blue	Colorless

Table 2 Indicator Composition 2 Colorants and Results after Sterilization

No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
20	[1]Amaranth	Monoazo	16185	Pink/gray	Pink/gray	Significantly lighter
21	[1]Rhodanine 6G	Xanthene	45160	Hot pink	Hot pink	Colorless
22	[5]Brilliant cresyl blue BB	Oxazine	51010	Blue	Blue	Colorless
23	[3]D & C red No. 33	Monoazo	17200	Red	Red	Colorless
24	[1]Bordeaux R	Monoazo	16180	Light pink	Light pink	Significantly lighter
25	[1]Direct red 75	Diazo	25380	Pale pink	Pale pink	Colorless
26	[1]Acid violet 7	Monoazo	18055	Lilac	Lilac	Colorless
27	[1]Acid violet 5	Monoazo	18125	Dark pink	Dark pink	Colorless
28	[1]Plasmocorinth B	Monoazo	16680	Dark pink	Brown	Colorless
29	[1]Brilliant crocein MOO	Diazo	27290	Orange	Orange	Colorless

Table 2 Indicator Composition 2 Colorants and Results after Sterilization

No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
30	[1]Methylene green	Thiazine	52020	Pale blue/gray	Pale blue/gray	Colorless
31	[1]Methylene violet 3RAX	Diazine	50206	Pink	Pink	Colorless
32	[1]Ponceau SS	Diazo	27190	Pink/beige	Pink/beige	Colorless
33	[1]Reactive black 5	Diazo	20505	Blue/black	Blue/black	Colorless
34	[2]Basic red 15	Not known	Not known	Hot pink	Hot pink	Colorless
35	[3]Acid green AX986	Not known	Not known	Lime green	Lime green	Colorless
36	[1]Lissamine green B (*Acid Green 50 or Wool Green S)*	Methane	44090	Blue/green	Blue/green	Colorless
37	[1]Erioglaucine	Methane	42090	Blue/green	Blue/green	Colorless
38	[1]Violamine R	Xanthene	45190	Light pink	Pink/Violet	Colorless
39	[1]Brilliant black BN	Diazo	28440	Dark gray	Dark gray	Colorless

Table 2 Indicator Composition 2 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
40	[1]Arsenazo 111	Diazo	None	Dark lilac	Dark gray	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4] Commercially available from Warner-Jenkinson, St. Louis, MO.

[5] Commercially available from Kodak, Rochester, NY

Table 3a Control Indicator B Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
1	[1]Azocarmine G	Diazine	50085	Purple/pink	None
2	[1]Ethyl violet (*Basic violet 4)*	Methane	42600	Dark purple/blue	None
3	[1]Victoria pure blue BO (*Basic blue 7)*	Methane	42595	Blue	None
4	[1]Nile blue A	Oxazine	51180	Lilac	Slightly lighter
5	[1]Quinaldine red	Cyanine	None	Muddy pink	Light pink
6	[3]Patent blue violet	Methane	None	Green/blue	None
7	[1]Acid fuchsin sodium salt	Methane	42685	Hot pink	Lighter
8	[1]Eriochrome black T	Monoazo	14645	Light muddy pink	None
9	[1]Eriochrome blue black B	Monoazo	14640	Muddy pink	None
10	[1]Aniline blue	Methane	42780	Blue	Gray/green
11	[1]Azure B	Thiazine	52010	Blue	Significantly lighter

Table 3a Control Indicator B Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
12	[1]Guinea green B *(Acid green 3)*	Methane	42085	Green	Almost colorless
13	[4]D & C green No. 5	Anthraquinone	Not known	Pale green	None
14	[4]Keystone soap fluoro green	Not known	Not known	Light green	None
15	[1]Congo red	Diazo	22120	Red	None
16	[1]Acid blue 113	Diazo	26360	Blue/gray	None
17	[1]Acid red 151	Diazo	26900	Pink	None
18	[1]Arsenazo 1	Monoazo	None	Light pink	Slightly lighter
19	[1]Methylene violet 3RAX	Diazine	50206	Pink	None
20	[1]Mordant brown 48	Monoazo	11300	Very light orange	None
21	[2]Basic red 14	Not known	Not known	Pink	Slightly lighter
22	[2]Basic red 15	Not known	Not known	Pink	Slightly lighter
23	[1]Fast green FCF	Methane	42053	Green	None

Table 3a Control Indicator B Colorants and Results after Sterilization					
No.	Colorant	Colorant Class	Color Index Number	Initial Color without Metallic Salts	Color Change in Sterilizer
24	[1]Erioglaucine	Methane	42090	Green/blue	None
25	[3]Alkali blue 4B	Methane	42750	Blue	Slightly lighter
26	[3]Coomassie violet R 150	Methane	42650	Grey/blue	None
27	[1]Acid blue 92	Monoazo	13390	Lilac	Light violet
28	[1]Acid blue 29	Diazo	20460	Grey/blue	None
29	[1]Xylidine ponceau 2R	Monoazo	16150	Orange	None
30	[1]Reactive blue 2	Anthraquinone	61211	Blue/gray	None

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4] Commercially available from Keystone Aniline Corp., Chicago, IL.

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Table 3b Indicator Composition 3 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cobalt Chloride	Color Change in Sterilizer
1	[3]Patent blue violet	Methane	None	Green/blue	Green/blue	Colorless
2	[1]Aniline blue	Methane	42780	Blue	Blue	Colorless
3	[1]Congo red	Diazo	22120	Dark orange	Dark orange	Colorless
4	[1]Arsenazo 1	Monoazo	None	Light Pink	Grey	Colorless
5	[1]Acid blue 92	Monoazo	13390	Lilac	Lilac	Colorless
6	[1]Acid blue 29	Diazo	20460	Gray/blue	Gray/blue	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

Table 4 Indicator Composition 4 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cobalt Acetate	Color Change in Sterilizer
1	[1]Nile blue A	Oxazine	51180	Lilac	Lilac	Colorless
2	[1]Eriochrome blue black B	Monoazo	14640	Muddy pink	Light violet	Colorless
3	[4]D & C green No. 5	Anthraquinone	Not known	Light green	Light green	Colorless
4	[2]Basic red 15	Not known	Not known	Pink	Pink	Colorless
5	[1]Erioglaucine	Methane	42090	Green/blue	Green/blue	Colorless
6	[1]Reactive blue 2	Anthraquinone	61211	Blue/gray	Blue/gray	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4]Commercially available from Keystone Aniline Corp., Chicago, IL.

Table 5 Indicator Compositios 5 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Chloride	Color Change in Sterilizer
1	[1]Azocarmine G	Diazine	50085	Rose	Light rose	Colorless
2	[1]Victoria pure blue BO (*Basic blue 7)*	Methane	42595	Blue	Dank blue	Colorless
3	[1]Acid fuchsin sodium salt	Methane	42685	Hot pink	Pink	Colorless
4	[4]D & C green No. 5	Anthraquinone	Not known	Pale green	Very pale green	Colorless
5	[4]Keystone soap fluoro green	Not known	Not known	Light green	Light green	Colorless
6	[2]Basic red 14	Not known	Not known	Pink	Pink	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4]Commercially available from Keystone Aniline Corp., Chicago, IL.

Table 6 Indicator Composition 6 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Sulfate	Color Change in Sterilizer
1	[2]Patent blue violet	Methane	None	Green/blue	Green/blue	Green/gray
2	[1]Azure B	Thiazine	52010	Blue	Blue	Clear
3	[1]Guinea green B *(Acid green 3)*	Methane	42085	Green	Green	Mottled green on clear
4	[1]Methylene violet 3RAX	Diazine	50206	Pink	Pink	Almost colorless
5	[2]Basic red 15	Not known	Not known	Pink	Pink	Significantly lighter
6	[1]Fast green FCF	Methane	42053	Green	Green	Mottled green on clear

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

Table 7 Indicator Composition 7 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Chloride	Color Change in Sterilizer
1	[1]Azocarmine G	Diazine	50085	Rose	Light rose	Colorless
2	[1]Victoria pure blue BO (*Basic blue 7)*	Methane	42595	Blue	Dark blue	Colorless
3	[1]Acid fuchsin sodium salt	Methane	42685	Hot pink	Pink	Colorless
4	[4]D & C green No. 5	Anthraquinone	Not known	Pale green	Very pale green	Colorless
5	[4]Keystone soap fluoro green	Not known	Not known	Light green	Light green	Colorless
6	[2]Basic red 14	Not known	Not known	Pink	Pink	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

[4]Commercially available from Keystone Aniline Corp., Chicago, IL.

Table 8 Indicator Composition 8 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Ferrous Sulfate	Color Change in Sterilizer
1	[2]Patent blue violet	Methane	None	Green/blue	Green/blue	Significantly. Lighter
2	[1]Eriochrome black T	Monoazo	14645	Light muddy pink	Light brown	Colorless
3	[1]Eriochrome blue black B	Monoazo	14640	Muddy pink	Pale pink	Colorless
4	[1]Acid blue 113	Diazo	26360	Blue/gray	Blue/gray	Colorless
5	[1]Acid red 151	Diazo	26900	Pink	Pink	Almost Colorless
6	[3]Alkali blue 4B	Methane	42750	Blue	Blue	Significantly. lighter

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

Table 9 Indicator Composition 9 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Chromium Potassium Sulfate	Color Change in Sterilizer
1	[1]Ethyl violet (*Basic violet 4)*	Methane	42600	Dark purple/blue	Dark purple/blue	Colorless
2	[1]Quinaldine red	Cyanine	None	Muddy pink	Muddy pink	Colorless
3	[1]Eriochrome black T	Monoazo	14645	Very light muddy pink	Light muddy pink	Colorless
4	[1]Eriochrome blue black B	Monoazo	14640	Muddy pink	Muddy pink	Colorless
5	[1]Congo red	Diazo	22120	Red	Red	Brown
6	[1]Acid blue 113	Diazo	26360	Blue/gray	Blue/gray	Colorless

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

Table 10 Indicator Composition 10 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Acetate	Color Change in Sterilizer
1	[1]Acid red 151	Diazo	26900	Pink	Very pale pink, almost clear	Lighter
2	[1]Mordant brown 48	Monoazo	11300	Very Light Orange	Cream	Lighter
3	[3]Coomassie violet R 150	Methane	42650	Gray/blue	Purple	Almost colorless
4	[1]Acid blue 29	Diazo	20460	Purple	Pale purple	Lighter
5	[1]Xylidine ponceau 2R	Monoazo	16150	Orange	Yellow	None
6	[1]Reactive blue 2	Anthraquinone	61211	Blue/gray	Blue/gray	Slightly lighter

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

[2]Commercially available from Spectra, Kearny, NJ.

[3]Commercially available from ICN Biomedicals, Costa Mesa, CA.

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Table 11 Indicator Composition 11 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Acetate	Color Change in Sterilizer
1	Evans blue	Diazo	23860	Bright blue	Bright blue	Muddy light purple
2	Acid violet 7[1]	Monoazo	18055	Magenta	Very dark pink	Pale yellow with a slightly pink center
3	Naphthol blue black	Diazo	20470	Navy blue	Dark blue	Dark purple
4	Reactive black 5[1]	Diazo	20505	Blue	Blue	Pink*
5	Brilliant black BN[1]	Diazo	28440	Dark blue	Dark blue	Off-white with light blue center
6	Brilliant black BN[1]	Diazo	28440	Dark blue	Dark blue	Off-white*
7	Azocarmine B	Diazine	50090	Fuchsia	Tan	Yellow with a purple center
8	Azocarmine B	Diazine	50090	Fuchsia	Tan	Yellow*

*Indicator without adhesive

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

Table 12 Indicator Composition 12 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cobalt Acetate	Color Change in Sterilizer
1	Cibacron brilliant red 3B[1]	Monoazo	18105	Fuchsia	Fuchsia	Muddy yellow-green with a pink center
2	Evans blue	Diazo	23860	Bright blue	Bright blue	Muddy brown with a slightly blue center
3	Reactive black 5[1]	Diazo	20505	Blue	Blue	Pale blue with white edges
4	Reactive black 5[1]	Diazo	20505	Blue	Blue	Pale spotty blue with white edges*
5	Brilliant black BN[1]	Diazo	28440	Dark blue	Dark blue	Muddy light brown with slightly blue center

*Indicator without adhesive

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

Table 13 Indicator Composition 13 Colorants and Results after Sterilization						
No.	Colorant	Colorant Class	Color Index Number	Initial Color	Color with Cupric Sulfate	Color Change in Sterilizer
1	Evans blue	Diazo	23860	Bright blue	Bright blue	Dark Blue
2	Acid violet 7[1]	Monoazo	18055	Magenta	Magenta	Pale pink
3	Acid violet 7[1]	Monoazo	18055	Magenta	Magenta	Pale yellow*
4	Naphthol blue black	Diazo	20470	Navy blue	Navy blue	Muddy magenta with tan spots*
5	Reactive black 5[1]	Diazo	20505	Blue	Blue	Dark pink
6	Brilliant black BN[1]	Diazo	28440	Dark blue	Dark blue	Slight lighter blue
7	Azocarmine B	Diazine	50090	Fuchsia	Coral	Purple

*Indicator without adhesive.

[1]Commercially available from Sigma-Aldrich Fine Chemicals, St. Louis, MO.

The complete disclosures of the patents, patent documents, and publications cited herein are incorporated by reference in their entirety as if each were individually incorporated. Various modifications and alterations to this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention. It should be understood that this invention is not intended to be unduly limited by the illustrative embodiments and examples set forth herein and that such examples and embodiments are presented by way of example only with the scope of the invention intended to be limited only by the claims set forth herein as follows.